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Satellite Image Deep Fake Creation and Detection

Brady Wachs

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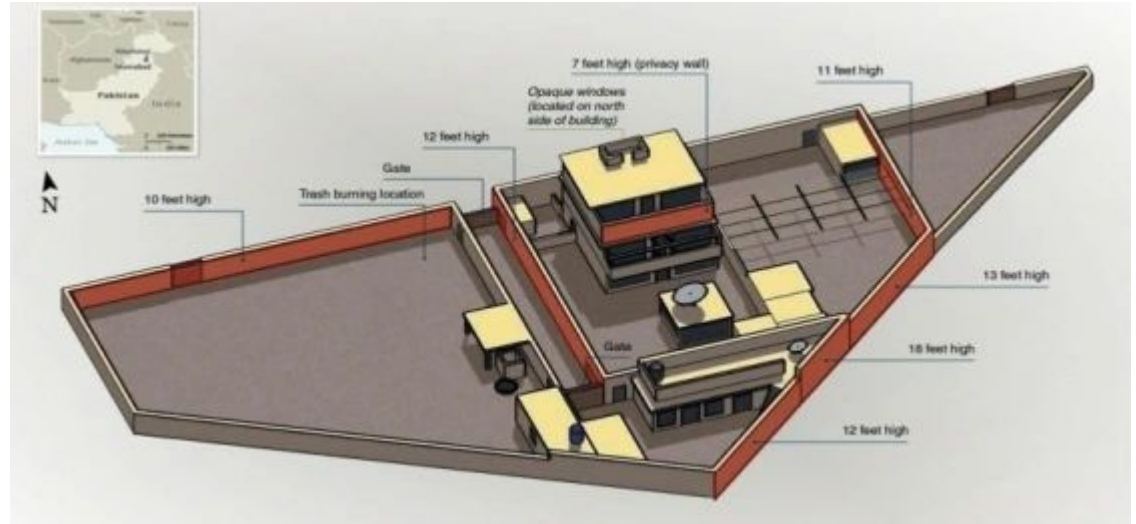
August 5th, 2021

MH17 Crash



www.bellingcat.com

Satellite Images For Intelligence

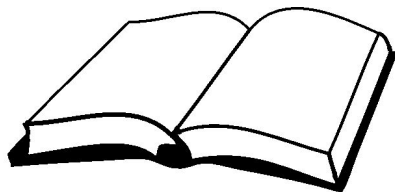


<https://www.nbcnews.com/science/cosmic-log/how-satellites-helped-get-osama-flna6c10403193>

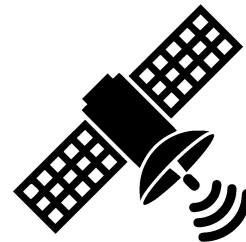
Overview



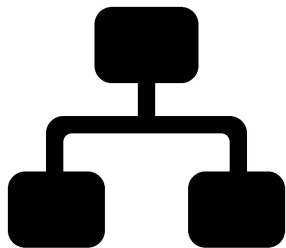
Importance



Background



The Dataset



Classification Model

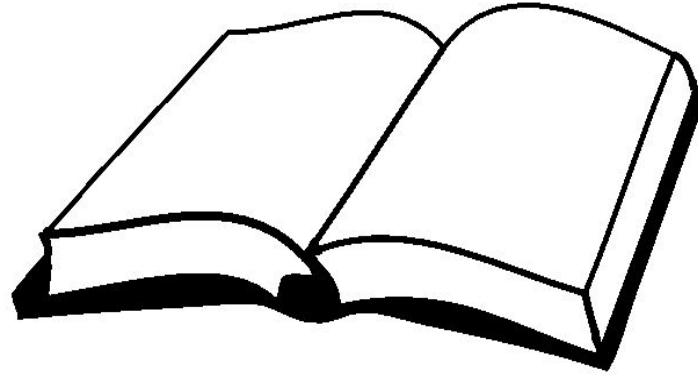


Image Inpainting



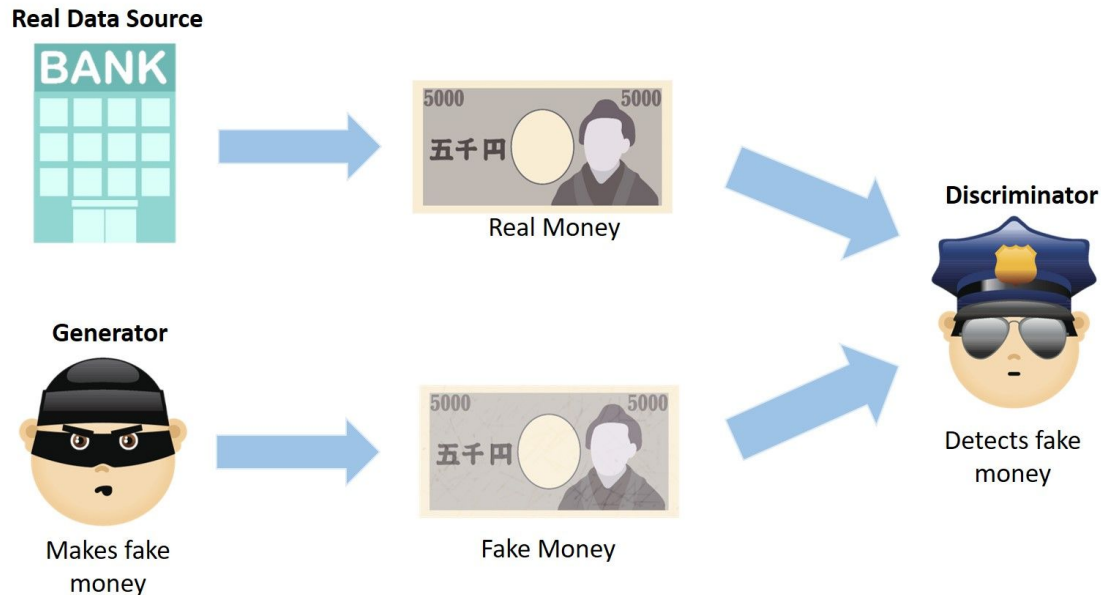
Results

Background



https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.seekpng.com%2Fipng%2Fu2w7t4u2w7y3y3i1_open-book-clipart-black-and-white-clipart-panda%2F&psig=AOvVaw1_2rwkQj2trIFNUqxM1Yd2&ust=1627749039144000&source=images&cd=vfe&ved=0CAsQjhxqFwoTCKD7mfKci_ICFQAAAAAdAAAAABAD

What is a GAN?



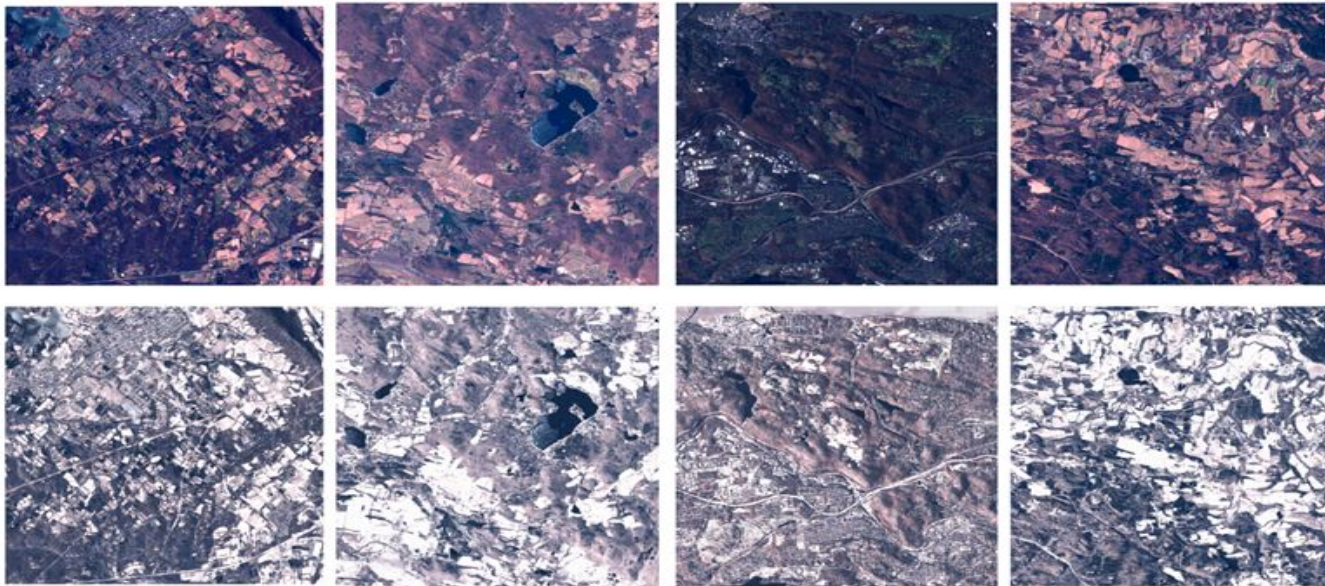
https://www.macnica.co.jp/business/ai_iot/columns/135130/

What is a Deep Fake?



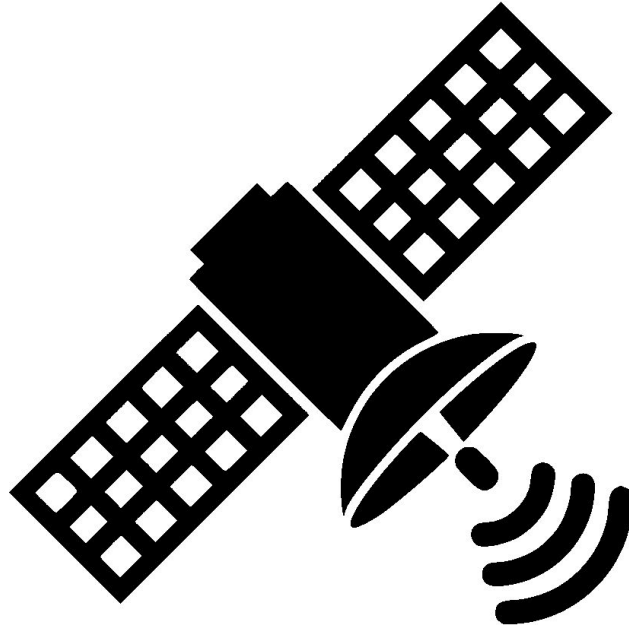
<https://www.thispersondoesnotexist.com/>

Synthetic Changes



Source: Deep Snow: synthesizing remote sensing imagery with generative adversarial nets, Ren *et al.* (2020)

The Dataset



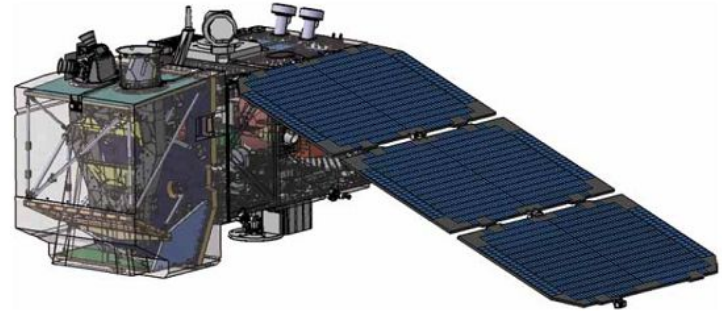
https://www.google.com/url?sa=i&url=https%3A%2F%2Favpng.com%2Fpng_view%2Fsatellite-radio-communications-satellite-clip-art-png%2FSCsqj0C&psig=AOvVaw0ugNenpl6HVmAXApW5Uia&ust=1628128774603000&source=images&cd=vfe&ved=0CAsQjhxqFwoTCKiGgcCilviCFQAAAAAdAAAAABAJ

SEN12MS



Sentinel-1

Synthetic Aperture Radar (SAR)



Sentinel-2

Multi-spectral Instrument (MSI)

<https://sentinel.esa.int/web/sentinel/missions/>



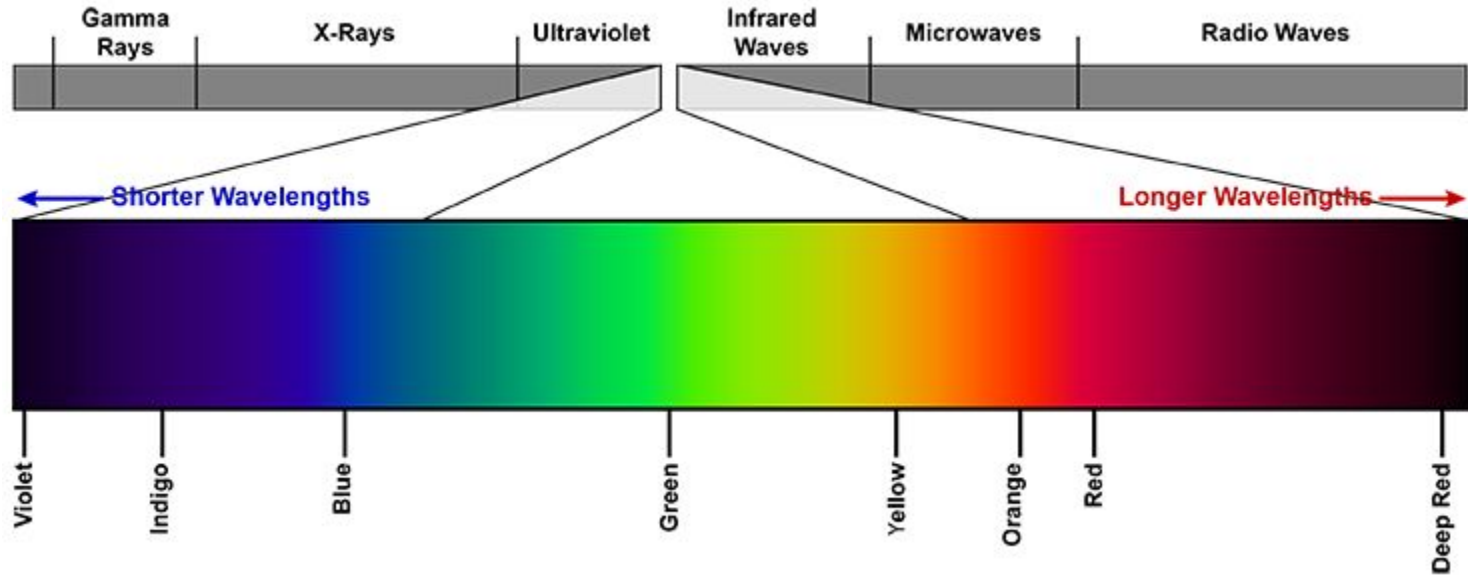
Sentinel-1 Image



Sentinel-2 Image

Source: Remote Sensing Image Classification With The SEN12MS Dataset, *Schmitt et al. (2021)*

Multi-Spectral Imaging



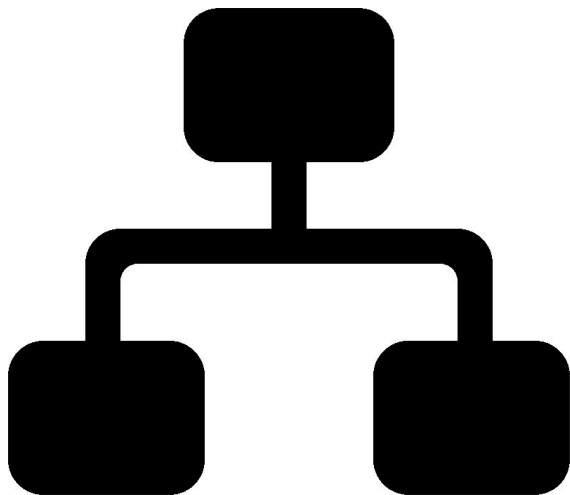
https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.weather.gov%2Fjetstream%2Fcolor&psig=AOvVaw15yiiEEPLoMuzk7j_cPji-&ust=1628130462046000&source=images&cd=vfe&ved=0CAsQjhxqFwoTCMC2z--olviCFQAAAAAdAAAAABAE

Benefits of Multi-Spectral Images



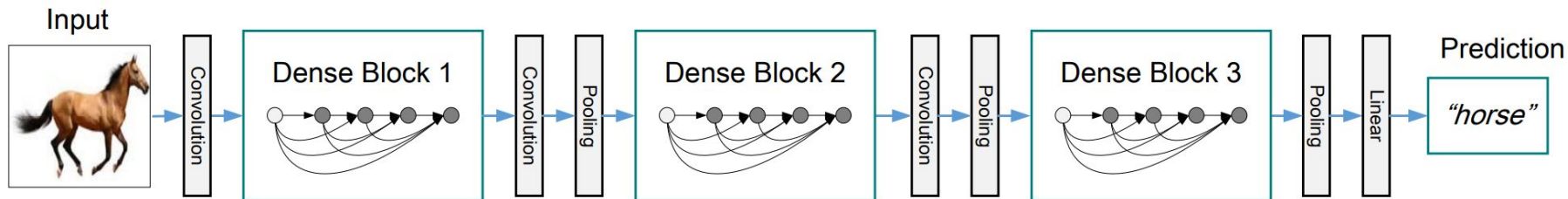
<https://gisgeography.com/sentinel-2-bands-combinations/>

Classification Model



https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.pinterest.com%2Fpindetail%2FombwJh_svg-black-and-white-library-classification-frames-illustrations%2F&psig=AOvVaw1Ul4ixUogi4J8UwW9clqXc&ust=1627749488957000&source=images&cd=vfe&ved=0CAsQjhqFwoTCICNw86di_ICFQAAAAAdAAAAABAD

DenseNet



https://www.google.com/url?sa=i&url=https%3A%2F%2Fpaperswithcode.com%2Fmethod%2Fdensenet&psig=AOvVaw1CdpauOYt0U9XoXYnF_VSD&ust=1628175933203000&source=images&cd=vfe&ved=0CAsQjhqFwoTCLjuyZfSI_ICFQAAAAAdAAAAABAV



Sentinel-2 Natural
Color



IGBP Land Cover



Source: SEN12MS - A Curated Dataset of Georeferenced Multi-spectral Sentinel-1/2 Imagery For Deep Learning and Data Fusion, **Schmitt *et al.* (2019)**

Generative Image Inpainting



https://www.google.com/url?sa=i&url=http%3A%2F%2Fwww.clipartsuggest.com%2Fpaint-brush-clip-art-black-and-white-clipart-panda-free-clipart-5fJJdus-clipart%2F&psig=AOvVaw0boyFvo7TGtnRJFe8CsFT&usq=1627749779398000&source=images&cd=vfe&ved=0CAsQihxqFwoTCJCCpqSfi_ICFQAAAAAdAAAAABAD

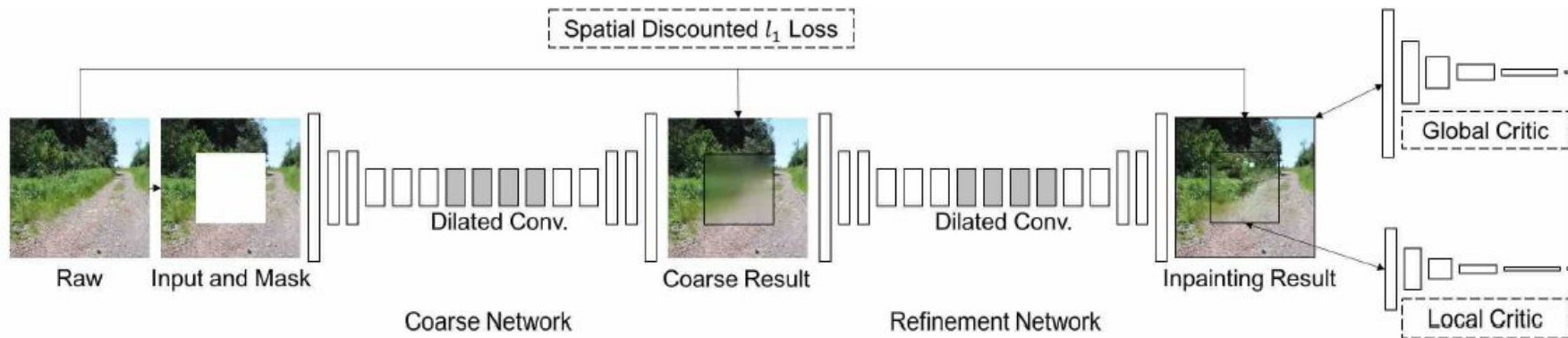
What is Image Inpainting?



Filling in missing pixels in an image

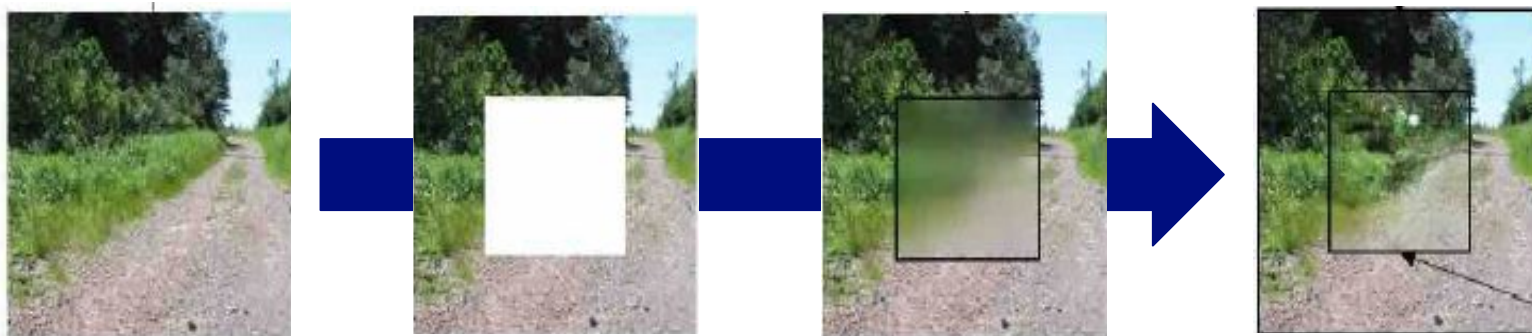
Source: Generative Image Inpainting with Contextual Attention, Yu *et al.* (2018)

Model Architecture



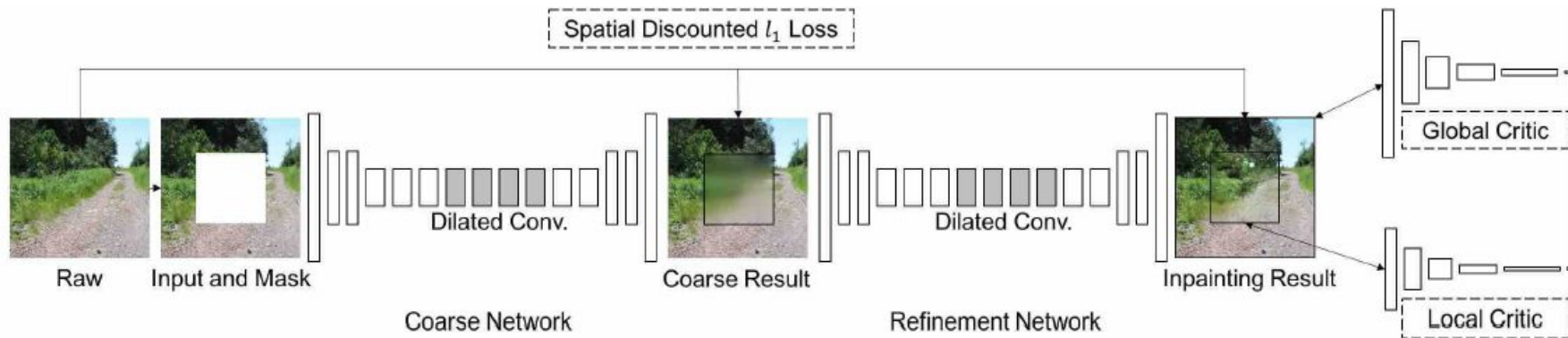
Source: Generative Image Inpainting with Contextual Attention, Yu *et al.* (2018)

Inpainting Process



Source: Generative Image Inpainting with Contextual Attention, Yu *et al.* (2018)

Model Architecture



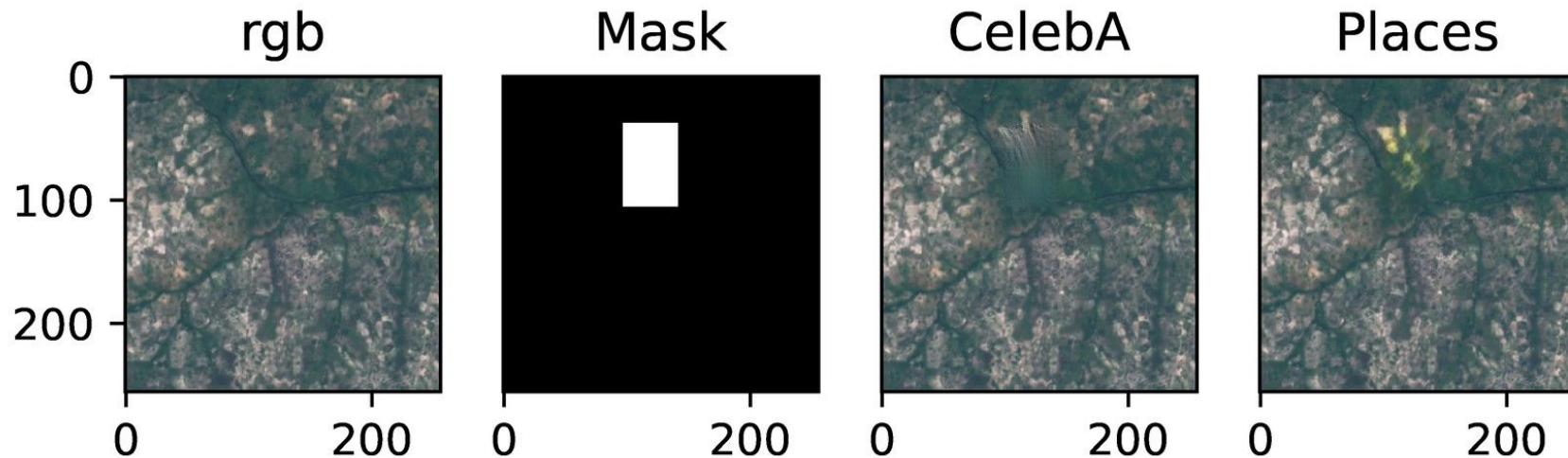
Source: Generative Image Inpainting with Contextual Attention, Yu *et al.* (2018)

Results



https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.kindpng.com%2Fimgv%2FTxomhwR_clipboard-checklist-png-clipart-patient-reported-outcomes-icon%2F&psig=AOvVaw07f2xqbdBtG5k9DOdLlfB5&ust=1627749884851000&source=images&cd=vfe&ved=0CAsQjhxqFwoTCLiwlqyfi_ICFQAAAAAdAAAAABAJ

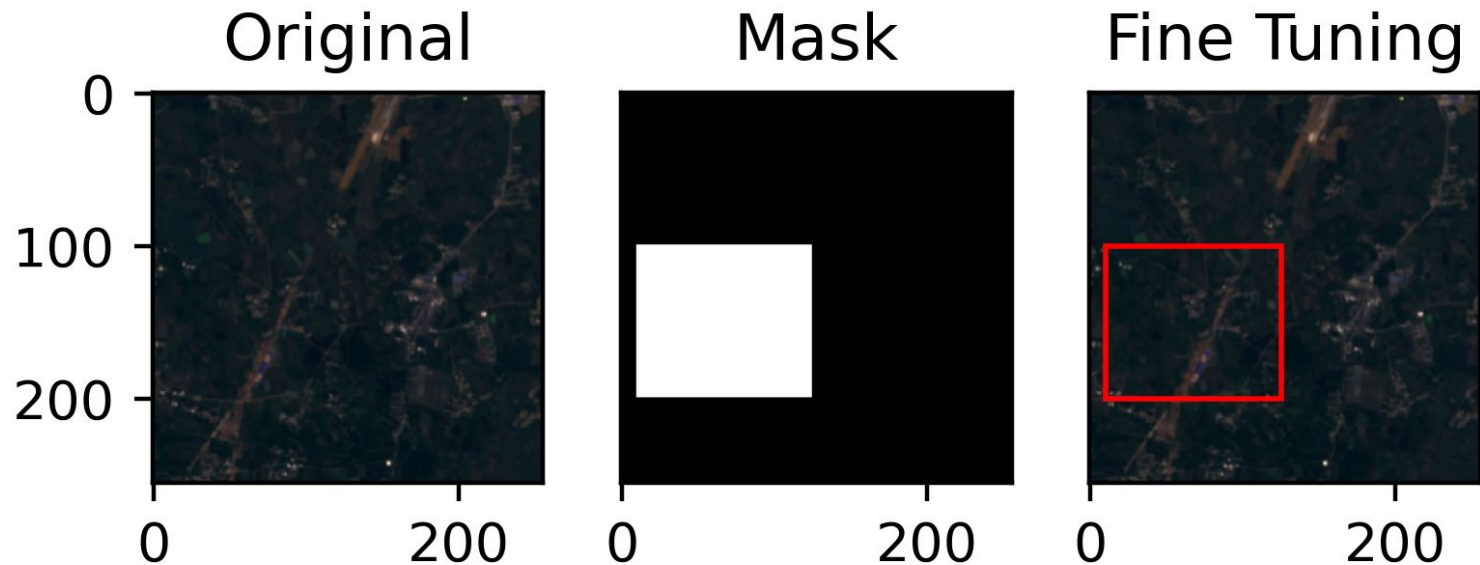
Results With No Fine Tuning

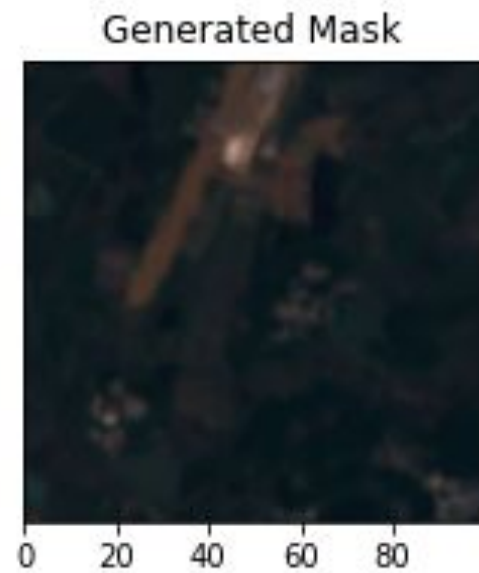


Preliminary Results with Fine Tuning



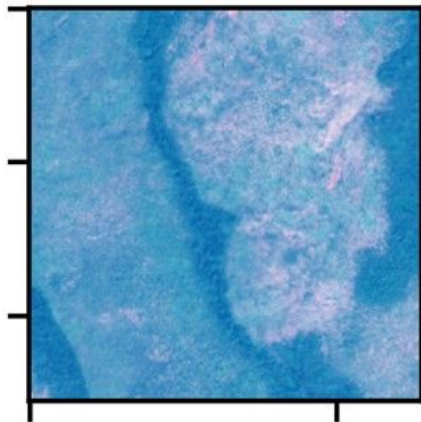
Preliminary Results with Fine Tuning



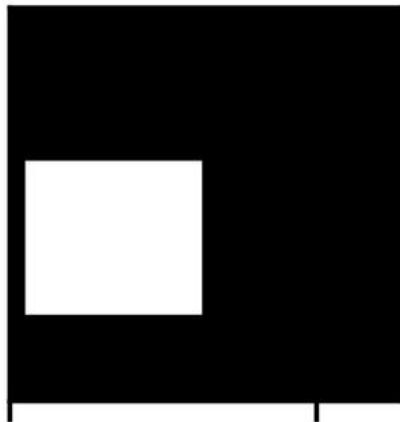


Testing on New Data

Original



Mask

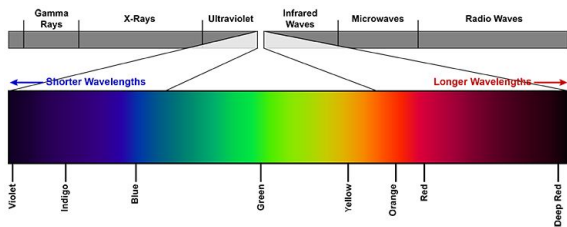


Fine Tuning

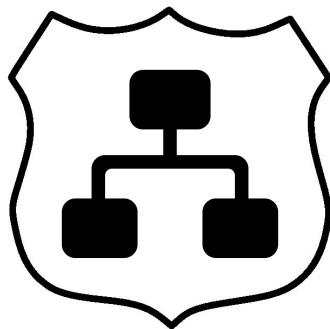


Quantitative Results

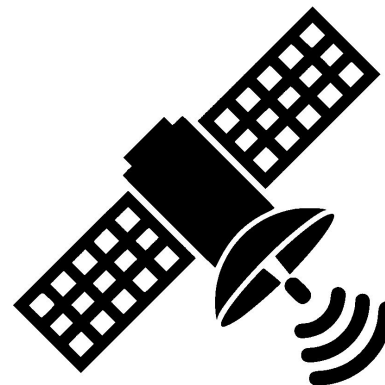
Future Work



Generate images in
multi-spectral space



Create a more
robust classification
model

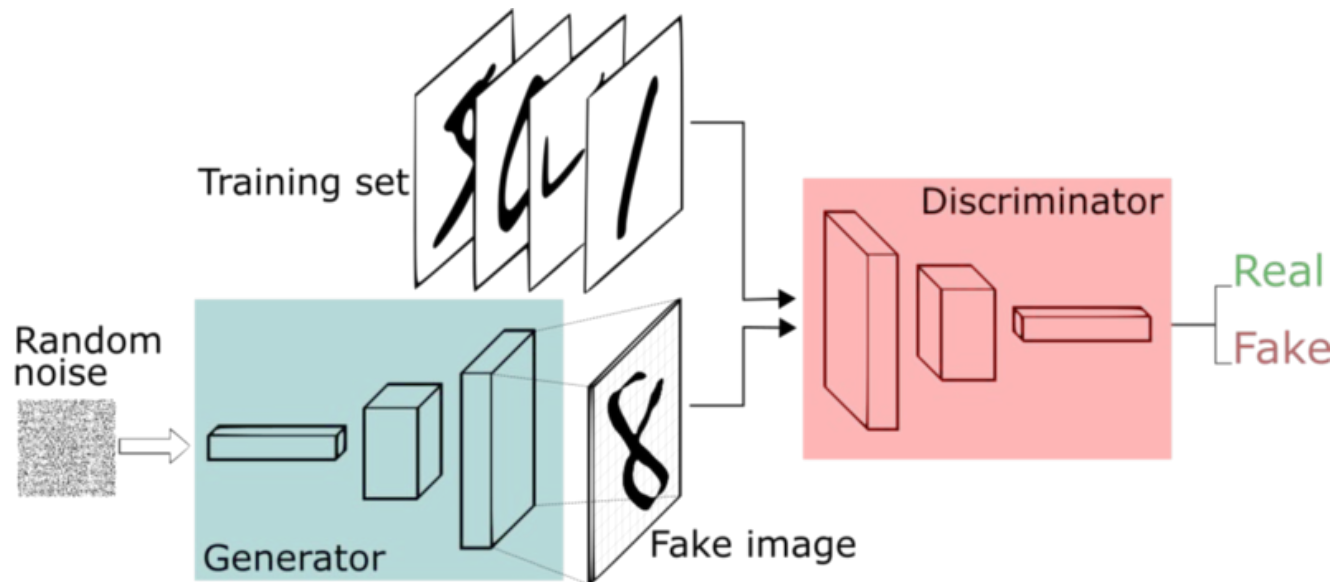


Expand work to
other datasets

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.clipartmax.com%2Fmiddle%2Fm2K9A0b1m2A0H7G6_police-shield-clip-art-police-shield-clipart%2F&psig=AOvVaw3f6Cgv2op7IDqpxgeScmu4&ust=1628177156819000&source=images&cd=vfe&ved=0CAsQjhqFwoTCLirmdrWI_ICFQAAAAAdAAAAABAT

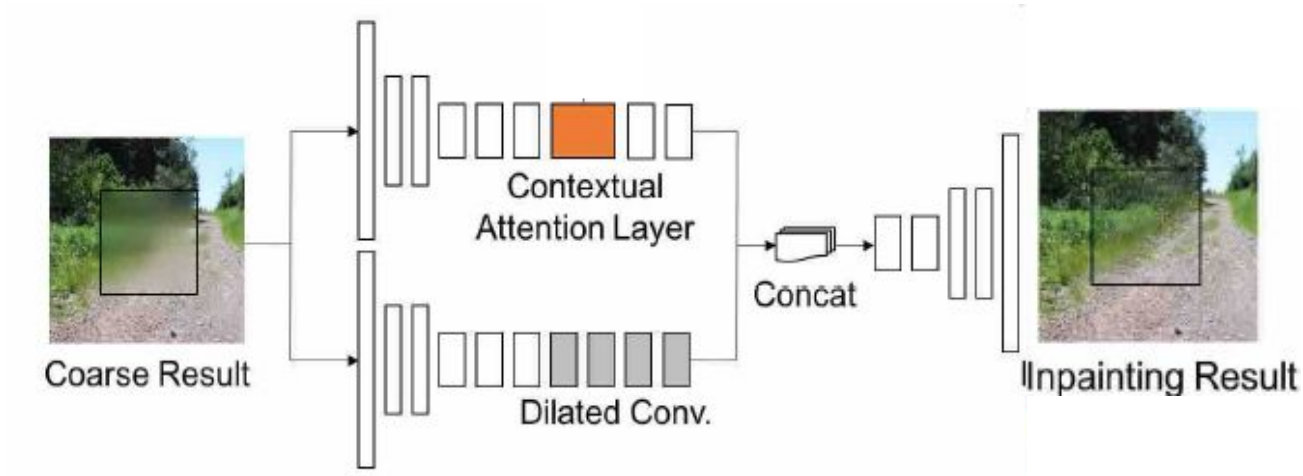
Hidden Slides

What is a GAN?

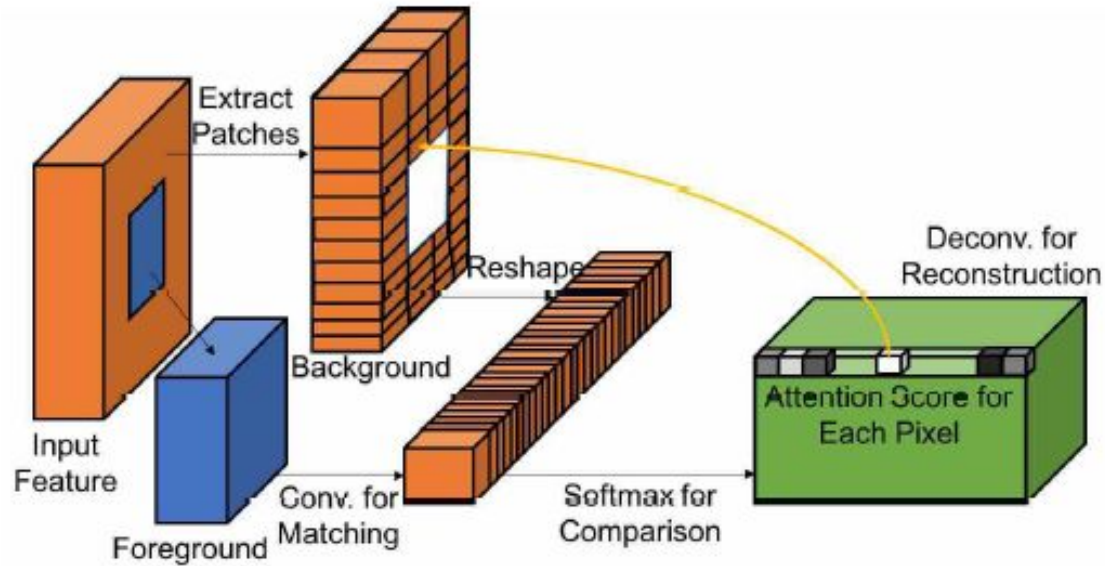


<https://www.flaticon.com/download/icon/landing/4841590?format=png&size=512>

Parallel Encoder Network



Contextual Attention Layer



Source: Generative Image Inpainting with Contextual Attention, Yu *et al.* (2018)

State-of-the-Art Model Comparison

Method	ℓ_1 loss	ℓ_2 loss	PSNR	TV loss
PatchMatch [3]	16.1%	3.9%	16.62	25.0%
Baseline model	9.4%	2.4%	18.15	25.7%
Our method	8.6%	2.1%	18.91	25.3%

Source: Generative Image Inpainting with Contextual Attention, Yu *et al.* (2018)